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(71) Applicant: APPLIED SCIENCE FICTION, INC. [US/US]; Suite 500, 3925 West Braker Road, Austin, TX 78759-5321 (US).		Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	
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(54) Title: SYSTEM AND METHOD FOR LATENT FILM RECOVERY IN ELECTRONIC FILM DEVELOPMENT			
(57) Abstract <p>Recovering the dye image on film in electronic film development following a latent holding stage obviates the problem common in prior art electronic film development of film image destruction. Recovery of the image is accomplished using a developing agent containing couplers to form a dye image. These dyes do not affect the infrared scans of the image. Upon complete development of the dye image, further dye formation is halted by the application of a coupler blocking agent, while silver development and electronic scanning may continue or halt. After halting dye formation, the film is stable for an arbitrary time in a latent stage and may be dried and stored. Following this latent stage, silver is removed from the film with a bleach-fix leaving a conventionally usable film image.</p>			

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01727

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : Please See Extra Sheet.

US CL : 430/357, 359, 363, 470; 396/600, 648; 358/496, 497, 501

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 430/357, 359, 363, 470; 396/600, 648; 358/496, 497, 501

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,576,836 A (SANO et al) 19 November 1996 at figures 1 and 5A and column 2, line 63 to column 10, line 46.	1-34
Y	US 5,447,811 A (BUHR et al) 05 September 1995 at figures 8 and 12 and column 2, line 51 to column 28, line 20.	1-34
Y, P	US 5,667,944 A (REEM et al) 16 September 1997 at figures 1 and 2 and column 6, line 15 to column 17, line 43.	1-34
Y, P	US 5,691,118 A (HAYE) 25 November 1997 at column 2, line 22 to column 12, line 39.	1-34
Y, P	US 5,695,914 (SIMON et al) 09 December 1997 at column 2, line 48 to column 23, line 2.	1-34

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
B earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*A* document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means	
P document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

03 SEPTEMBER 1998

Date of mailing of the international search report

14 OCT 1998

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01727

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E, Y	US 5,726,773 (MEHLO et al) 10 March 1998 at figures 3 and 4 and column 1, line 37 to column 7, line 63.	i-34
Y	US 5,212,512 (SHIOTA) 18 May 1993 at figures 1,2,3,4,6 and 10.	23-33
Y	US 5,231,439 (TANAHASHI et al) 27 July 1993 at figures 1,2,3,4,5, 10 and 12.	23-33

Form PCT/ISA/210 (continuation of second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01727

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐

The additional search fees were accompanied by the applicant's protest.

☒

No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01727

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

G03C 7/30, 7/407, 11/16; G03D 3/00, 15/02; H04N 1/04, 1/46

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

Group I, claims 1-20 and 23-33, drawn to a method for latent film recovery and for use with an apparatus.

Group II, claims 21-22, drawn to another distinctive method for a latent film recovery.

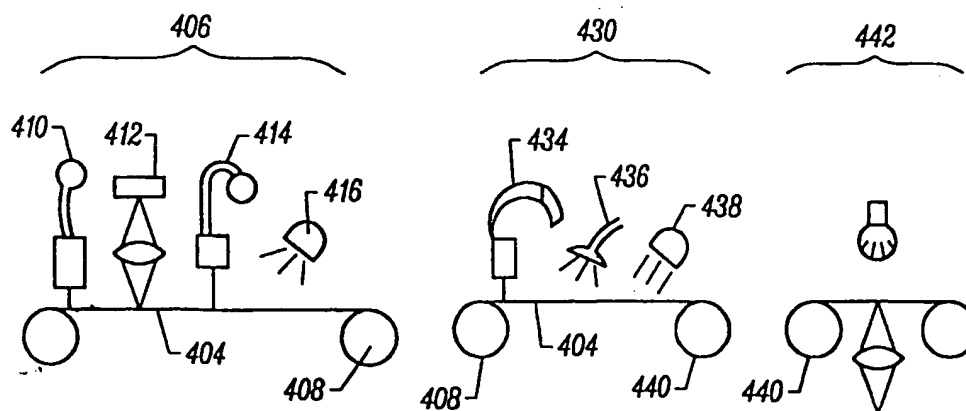
Group III, claim 34, drawn to another distinctive apparatus.

The inventions listed as Groups I, II and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical steps in the methods or features in the apparatus for the following reasons: (1) The main invention with respect to the method claims 1-20 requires (a) the use of the specific first developing agent containing a coupler and (b) a selected light for an illumination as compared to the distinctive method claims 21-22 which is distinctively required (a) the use of the specific first developing agent containing no coupler and (b) a coupler being applied in a later step. (2) The main invention with respect to the apparatus claims 23-33 requires (a) feed spool and (b) a coupler in activation station as compared to the distinctive apparatus claims 34 which is distinctively required (a) a means for applying the specific first developing agent containing no coupler and (b) a means for separately applying a coupler. Accordingly, each of the above inventions has acquired its own distinctively inventive steps and features. None of them is so linked to be or form a single inventive concept which is considered to be an obvious variation in the art that would be required no separate consideration or search in the art for the distinctive invention as divided by applicants in accordance with PCT Rule 13.1 and 13.2.



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(54) Title: **SYSTEM AND METHOD FOR LATENT FILM RECOVERY IN ELECTRONIC FILM DEVELOPMENT**

(57) Abstract

Recovering the dye image on film in electronic film development following a latent holding stage obviates the problem common in prior art electronic film development of film image destruction. Recovery of the image is accomplished using a developing agent containing couplers to form a dye image. These dyes do not affect the infrared scans of the image. Upon complete development of the dye image, further dye formation is halted by the application of a coupler blocking agent, while silver development and electronic scanning may continue or halt. After halting dye formation, the film is stable for an arbitrary time in a latent stage and may be dried and stored. Following this latent stage, silver is removed from the film with a bleach-fix leaving a conventionally usable film image.

SYSTEM AND METHOD FOR LATENT FILM RECOVERY IN ELECTRONIC FILM DEVELOPMENT

RELATED APPLICATION

5 This application claims the benefit of U.S. Provisional Application No. 60/036,988, filed January 30, 1997.

FIELD OF THE INVENTION

This invention relates to the electronic development of film and more particularly
10 to a system and method for recovering an image on film without destroying the film image.

BACKGROUND OF THE INVENTION

In conventional color film development, color film consists of multiple layers each sensitive to a different color of light. These layers contain grains of silver halide. Photons
15 of colored light appropriate to each layer render the grains reducible to elemental silver upon the application of a developing agent. Contained within the primary developer for negative films and in the secondary color developer for reversal, or color positive, films are couplers that combine with the reaction products of the silver halide reduction and with other couplers contained in each layer to produce specific dyes within the film.
20 These dyes form around the developing silver grains in the film and create dye clouds. Following color development, any remaining milky white unexposed silver halide is washed away in a "fix" solution and the reduced black grains of silver are washed away in a "bleach" bath. Usually the fix and bleach baths are combined into one. After all the silver is removed, a clear film remains with colored dye clouds articulating the colored
25 image.

In a color negative film, the first and only developer contains couplers to form a negative dye image at the same time as the negative silver image develops. The bleach-fix bath then removes both the developed silver and the undeveloped silver halide leaving only the negative color dye image. In color positive film, sometimes called transparency
30 or reversal film, the first developer does not contain couplers. This first developer uses up the exposed silver halide in areas of the film that were exposed leaving silver halide in areas of the film that were not exposed. This remaining silver halide is rendered developable either by exposing it to bright light or to a fogging chemical. A second developer that does contain couplers then reduces this remaining silver halide to silver
35 producing at the same time a dye image. The silver halide remains, and the dyes form, in areas of the film that did not receive light while no silver halide remains, and therefore no dyes form, in areas of the film that had originally received light. Thus, a positive image is formed for direct viewing following the fix and bleach steps.

In electronic film development (a method of developing film without forming dyes), the developing film is scanned at a certain time interval using infrared light so as not to fog the developing film, and also to see through antihalation layers. During development, color is derived from a silver image by taking advantage of the milky opacity of unfixed silver halide to optically separate the three color layers sensitive to blue, green, and red. This application will follow a convention of referring to the top of the three layers of the film as the "front" and the bottom layer closest to the substrate as the "back" or "rear." Viewed from the front during development, the front layer is seen clearly, while the lower layers are substantially occluded by the milky opacity of the front layer. Viewed from the rear during development, the back layer is seen, while the other layers are mostly occluded. Finally, when viewed with transmitted light, the fraction of light that does penetrate all three layers is modulated by all, and so contains a view of all three layers. If the exposures of "front", "back", and "through" views were mapped directly to yellow, cyan and magenta dyes, a pastelized color image would result. However, in digital development these three scans, "front", "back" and "through", are processed digitally using color space conversion to recover full color.

One problem with prior methods of electronic film development is that the film is typically consumed in the process. Because the developer chemicals used during typical electronic film development do not contain couplers, color dye clouds are not formed in the film. The lack of dye clouds renders the film useless once the traditional electronic film development process is complete. The present invention addresses this problem by providing a conventional color negative as a byproduct of electronic film development.

SUMMARY OF THE INVENTION

The present invention provides for the electronic scanning of a silver image on a color sensitive film while exposed to a developing agent. The developing agent contains couplers which form a dye image from the silver image. The light used during electronic scanning is chosen to be substantially unaffected by the dye image. Once the dye image has completely developed, further formation of the dye image is halted.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a cross-sectional view of the layers in color film and depicts the formation of dye clouds during the development process.

FIG. 1B is a cross-sectional view of the film shown in FIG. 1A undergoing further development without couplers.

FIG. 2 is a cross-sectional view of the film shown in FIG. 1A or FIG. 1B showing how dye clouds are isolated in color film fixing.

FIG. 3 is a graph depicting the spectral absorption of various dyes and silver grains.

FIG. 4 is a perspective view of the system of the present invention.

FIG. 5 is a perspective view of an alternate embodiment of the system shown in
5 FIG. 4.

FIG. 6 is a perspective view of an alternate embodiment of the system shown in
FIG. 5.

DETAILED DESCRIPTION

10 Turning now to FIG. 1A, a more detailed description of the key features of the present invention is provided. FIG. 1A shows a cross-sectional view of a film 100 which consists of a film base 102 over which a multi-layered emulsion 101 is coated. This emulsion is simplified for illustration purposes to have just three layers, 104, 106 and 108, each sensitive to one of the primary colors blue, green, and red, respectively. The
15 emulsion 101 is typically made of gelatin mixed with a milky cloud of silver halide 110. The silver halide 110 is divided into grains 111 which are embedded in each color sensitive layer 104, 106 and 108 of the emulsion 101. When the grains 111 are exposed to light corresponding to the color to which the layer is sensitive, the grains 111 in that layer are rendered developable and are reduced to elemental silver.

20 One such grain 112 has been exposed and reduced to elemental silver by the action of the developer. This grain 112 now appears as a black grain. The byproducts released by the reaction of the developer with the silver halide combine with other chemicals in the developer that are precursors to color dyes (here called couplers) and with additional couplers manufactured into and unique to each layer to form dyes. These dyes typically
25 form within a several micron diffusion distance around the silver grain 112 to produce what is called a dye cloud 114. The color of the dye depends on the couplers located within and unique to each layer of emulsion 101, and are arranged so the blue sensitive layer 104 develops yellow dye clouds, the green sensitive layer 106 develops magenta dye clouds, and the red sensitive layer 108 develops cyan dye clouds.

30 Another feature important to the present invention is illustrated in FIG. 1B. FIG. 1B shows a film 100 after it has been developed as described above in conjunction with FIG. 1A. Next, the film 100 is placed in a developer without the couplers. As a result of this second developer application, grains 116 in the emulsion 101 will continue to develop to elemental silver; however, there will be no corresponding formation of dye clouds due
35 to the lack of couplers. These grains 116 will be visible to the electronic film developing process but will leave no dye to add to the image after the silver is dissolved and washed away.

FIG. 2 illustrates a film 100 after a development process as previously described and from which the unexposed silver halide has been removed by a chemical (such as sodium thiosulfate). Such a chemical is commonly called a "fix". In addition, the elemental silver grains have been removed by another chemical commonly called a "bleach". The fix and bleach are typically combined in one solution, sometimes referred to as a "blix". Thus, the application of a fix and bleach isolates any dye clouds 114 in the film 100. It is important to note that at this point in the process, the same dye image would be produced if the film had only been exposed to the color developer described in conjunction with FIG. 1A as would result from further exposure to a second developer containing no coupler as described in FIG. 1B. This is due to the fact that only the dye clouds 114 remain after the blix has been applied to the film 100.

FIG. 3 charts the spectral absorption of typical dyes and of elemental silver by showing the transmission of different colors of light by various dyes and silver. Curve 302 in FIG. 3 shows that the elemental silver image absorbs all colors. This is why such an image is called a black and white image, and it must be bleached away before the colored dye image can be usefully seen. FIG. 3 also illustrates that only the elemental silver image absorbs infrared light thereby modulating that light into a scannable image. Under infrared light, the dyes used in film processing do not absorb the light, and are therefore undetectable in a scannable image as evidenced by curves 304, 306 and 308. This is important because it means that electronic film development conducted under infrared light can receive scans of the developing silver image completely independent of the formation of specific dyes. The dye clouds simply have no effect on an electronic film development scan if that scan is made at an infrared wavelength longer than about 780 nanometers. Thus, couplers can be added to a developer to form dye clouds without affecting the scans of electronic film development conducted under infrared light.

FIG. 4 discloses a system which includes stations for both electronic film development and the cessation of dye coupler development. A feed spool 402 feeds a film 404 containing an image through an electronic film developer 406 and onto a takeup spool 408. Station 410 applies a controlled amount of developer to the film 404. The applied developer includes color couplers. Such a developer is commonly available as the developer in the "C-41" process suite of chemicals manufactured by Eastman Kodak Company of Rochester, New York, among others. The film 404 with the applied developer advances to the infrared scanning station 412 which operates in accordance with the teachings of electronic film development such as the process described in U.S. Patent No. 5,519,510 issued to Edgar, the present inventor. There may be several such scanning stations 412, but only one has been illustrated for simplicity. Immediately following the last scanning station 412, further dye coupling is halted by applying a solution at station 414 that prevents further film development. One such solution is a 3% acetic acid wash

although others are commonly used in the industry. The advancing film 404 is dried at drying station 416 before being rolled up on spool 408 for storage.

After passing through the electronic film developer 406, the film 404 has a conventional dye image embedded in it which is masked by a combination of silver halide and silver grains. From this point on in the process, the system operator may choose to retrieve the film image by mounting the spool 408 on a fixer 430. In the fixer 430, the film 404, having undergone the process described thus far in connection with FIG. 4, is advanced by station 434 for application of a bleach fix solution. As earlier described, the bleach fix removes the unexposed silver halide and elemental silver grains from the film 404. This solution is commonly available as the bleach-fix in the "C-41" process suite of chemicals manufactured by Photocolor Corporation and others. Rinsing station 436 washes off the bleach fix, and station 438 dries the film 404 before it is wrapped onto spool 440 for storage. Film spool 440 can then be mounted on a conventional optical printer 442, a conventional scanner, a viewer, a sleeve machine to put the film into sleeves for longer storage, or on any device receiving normally processed film.

It should be noted that the fixer 430 can be manually operated by a user without the skills necessary to run a home darkroom. First, the film 404 is already developed and will not be affected by exposure to additional light, so no darkroom or dark tent is needed. Second, the application of bleach fix in this process is done to completion (i.e., until all remaining grains are removed), so precise timing and temperature control is not needed. When applying the bleach fix manually, the operator wraps the film around a spiral film reel such as that available from Kindermann and other manufacturers sold in camera shops. Then, the reel and film are submersed for several minutes in the bleach-fix at room temperature. Next, the spiral film reel is rinsed for a few minutes under running tap water, and then the film is hung up to dry. All of these steps may be performed in normal room light. The problem with environmental contamination from the silver remains the same as for conventional home darkrooms. As an alternative, the film may be returned to a commercial lab for the bleach fix step and printing.

As previously described, a single scanning station 412 is shown in FIG. 4 for simplicity. In accordance with the teachings of electronic film development, several such stations may be employed to scan the film at different stages of film development as further described in U.S. Patent No. 5,519,510. In FIG. 4, the last of these stages is shown placed before development is halted at station 414; however, a scanning station could also be placed after development is halted at station 414. With that said, for reasons of uniformity, it has been found that scanner 412 is best placed as close as possible to, but just before station 414. A limitation in the system of FIG. 4 is that the last electronic film developer scan is made coincident with the "normal" development of the film. With this first disclosed system, it is thus possible to get both an

underdeveloped, or "pulled," record of electronic film development and a normally developed record, but not an overdeveloped, or "pushed," record. The system shown in FIG. 5 removes this limitation.

FIG. 5 shows an alternate embodiment from FIG. 4 wherein the coupler halting solution applied at station 414 in FIG. 4 that terminates all development is replaced with a coupler halting solution that does not completely halt color development. This solution is applied at station 520 in FIG. 5. One such solution is a developer, such as HC-110 manufactured by Eastman Kodak Company, that does not contain couplers, and is applied in sufficient quantity to wash off the first developer that did contain couplers. In addition this second developer can be more concentrated or caustic to encourage shadow grains to develop. Another alternative is to apply a solution that does not interfere with the development but which blocks the further formation of dyes.

After color coupling is halted by the solution applied at station 520, color development ceases while development of the silver image continues. Scanning station 530 receives the overdeveloped record and reveals more shadow detail than would have been present in a normally developed film. In accordance with the methods of electronic film processing in general, this shadow detail can be combined with the normal and underdeveloped scans to produce a superior image. Following station 530, the developer can be dried on the film 404 and the film stored on spool 408. It does not matter after this point if the film 404 is exposed to light or if development continues slowly so long as no more dye forms. Any silver fog or chemical residue can be cleared in the subsequent fixing apparatus 430 to produce a negative that is optically printable with apparatus 442.

In a variation of FIG. 5, a developer which has no color couplers may be applied at station 410. This enables the production of a latent positive film. An example of this type of developer could be the first developer used in standard reversal processing, available from Eastman Kodak Company as the first developer in the "E6" suite of chemicals. The addition or omission of couplers to the film 404 makes no difference to the electronic film development scanning station 412. After normal development and at the time the reversal film would normally go through fogging and a second color developer, a developer containing couplers may be applied at station 520. The developer with couplers could actually consist of the first developer already on the film, with only the couplers themselves added by station 520. Alternatively, it may be desirable to alter or accelerate the developer action at this point in the process by adding additional chemicals. The goal at this point for forming the dye image is to render all remaining undeveloped silver halide developable into silver thereby simultaneously forming the dye image. Traditionally, the film is fogged before the second developer with couplers is applied, but it makes no difference to the final product in what order the remaining silver halide is reduced. In particular, it makes no difference to the end product if silver halide related to

2/4

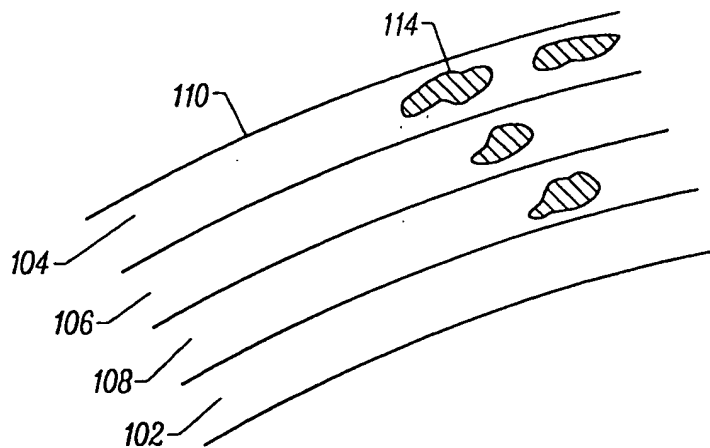


FIG. 2

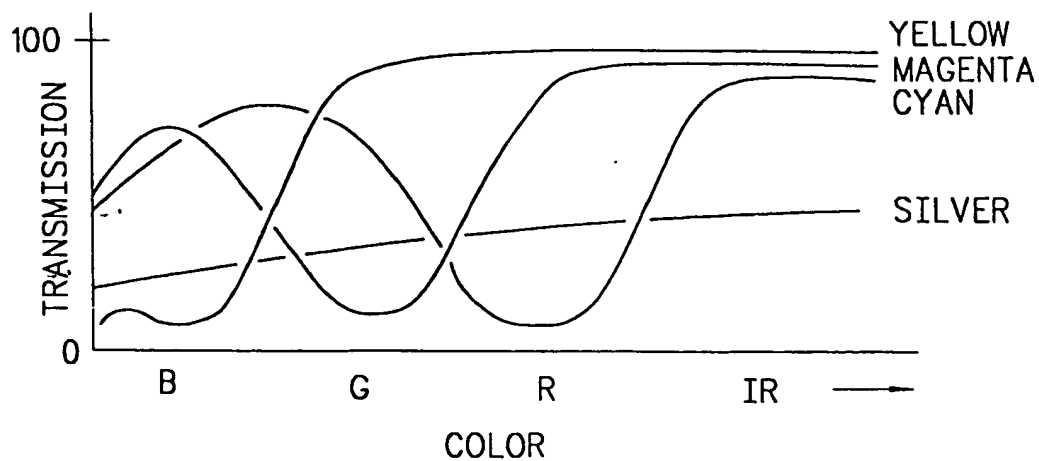


FIG. 3

3/4

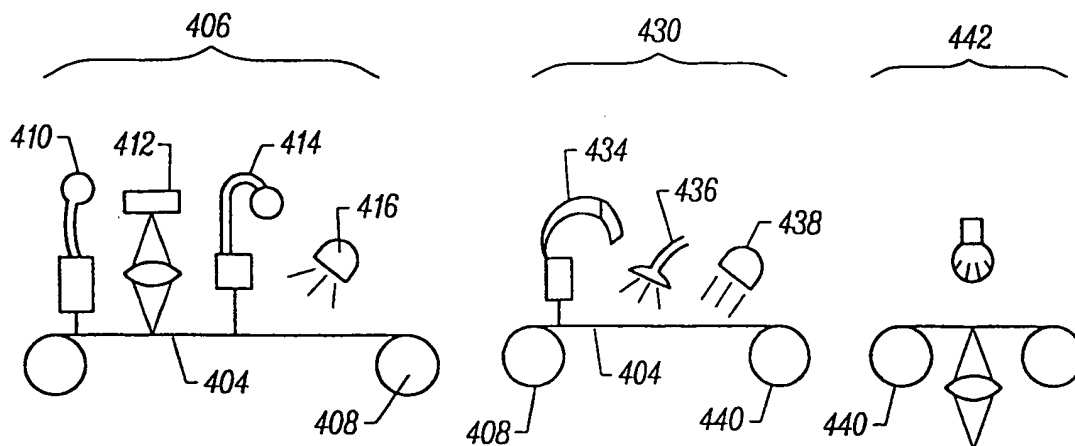


FIG. 4

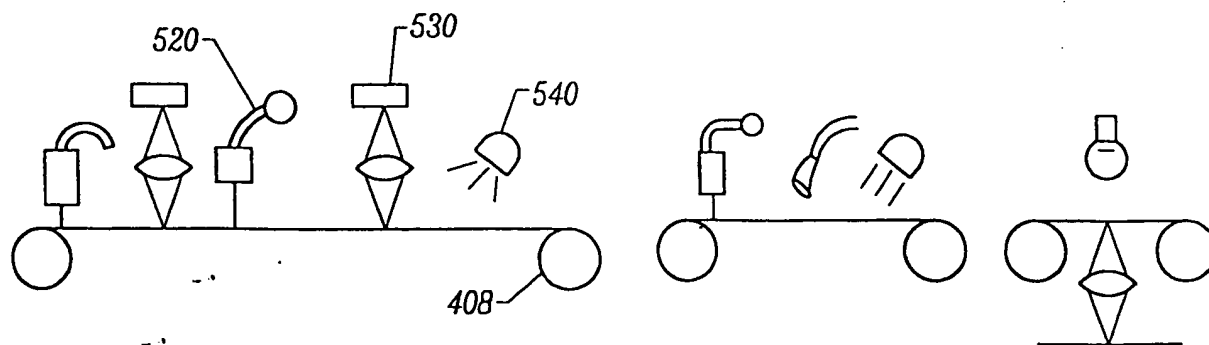


FIG. 5

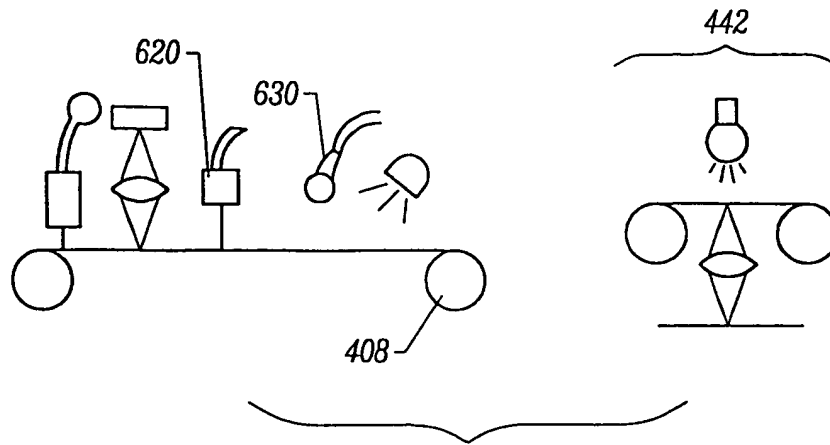


FIG. 6

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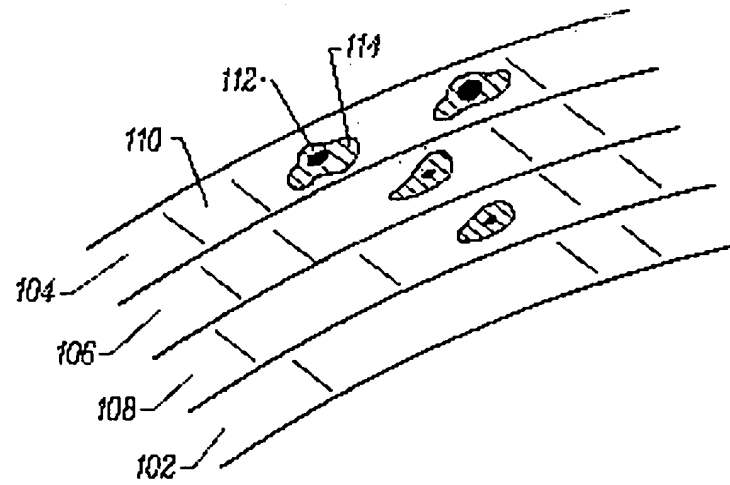


FIG. 1A

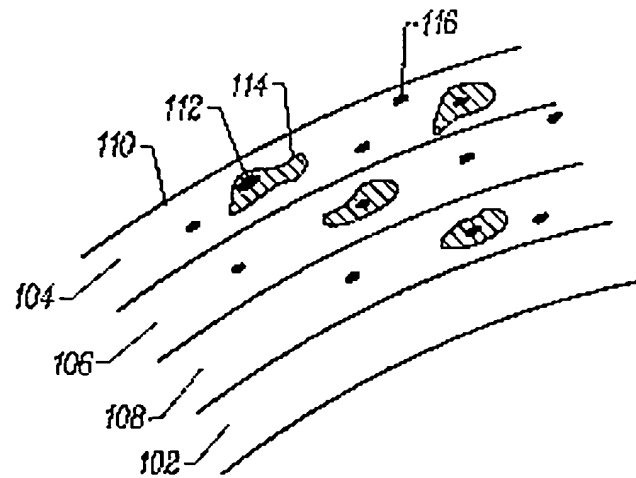


FIG. 1B

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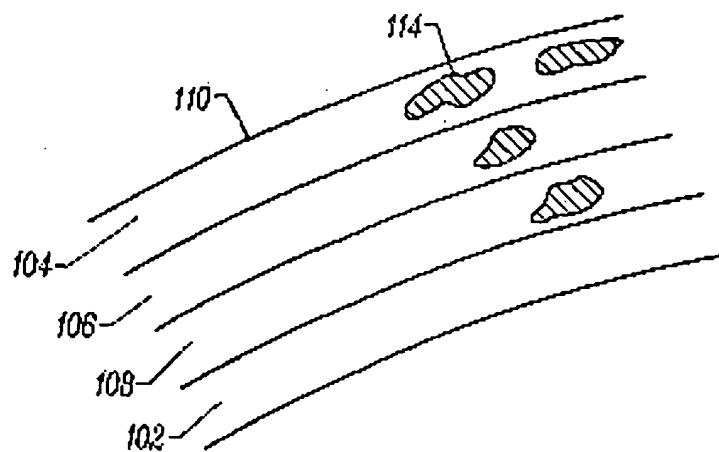


FIG. 2

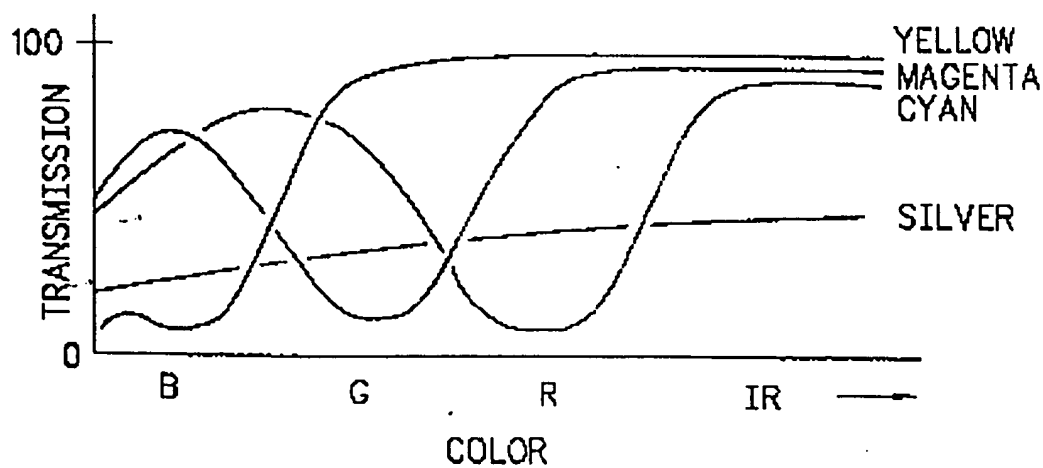


FIG. 3

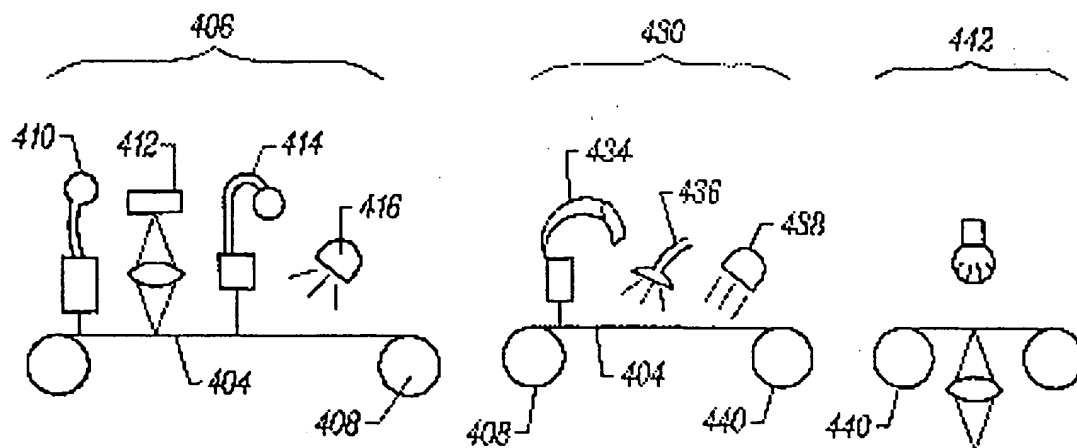


FIG. 4

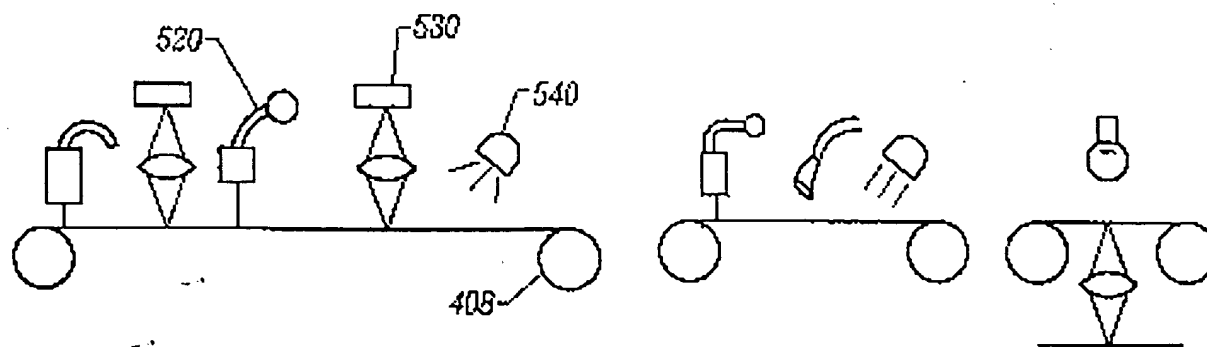


FIG. 5

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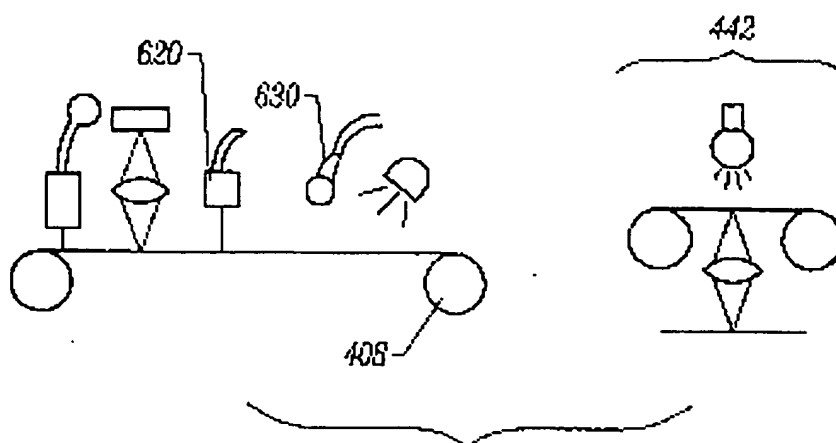


FIG. 6